Adaptive Spectral Band Integration in Thermographic Inspection of Composites

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Fiber reinforced polymers are composite materials that exhibit a high specific stiffness and a good corrosion resistance, which makes them particularly interesting for the transportation industry (e.g. aerospace sector). However, due to their typically layered structure, they are often prone to invisible internal damage features. In order to guarantee the structural health of these composite components, accurate and reliable non-destructive testing (NDT) techniques have been a hot area of development over the last few decades.

Flash thermography is a fairly recent but very promising NDT technique, in which the mismatch between the thermal properties of the sound material and an internal defect is exploited in order to detect hidden damages [1-3]. However, flash thermography is inherently limited by the diffusive and highly damped nature of the propagating thermal waves, making the detection of small and deep defects a challenging task. Pulsed Phase Thermography (PPT) [4] is one of the main post-processing techniques in the field of flash thermography, which significantly enhances the defect detectability. Typically, several phase images at different frequencies need to be evaluated in order to obtain a through-depth evaluation of the sample. However, the selection and subsequent evaluation of these images is cumbersome and not always straightforward. In order to overcome this shortcoming, the present communication treats a novel post-processing approach called 'Adaptive Spectral Band Integration' (ASBI) [5]. ASBI combines the various phase images in an optimal manner, and as such provides a unique damage map from which defects can be characterized.

A photograph of the coupon sample (GFRP, flat bottom hole defects covering a wide range of depths) and a schematic illustration of the experimental setup used to demonstrate the effectiveness of the novel ASBI algorithm are presented in Figure 1.

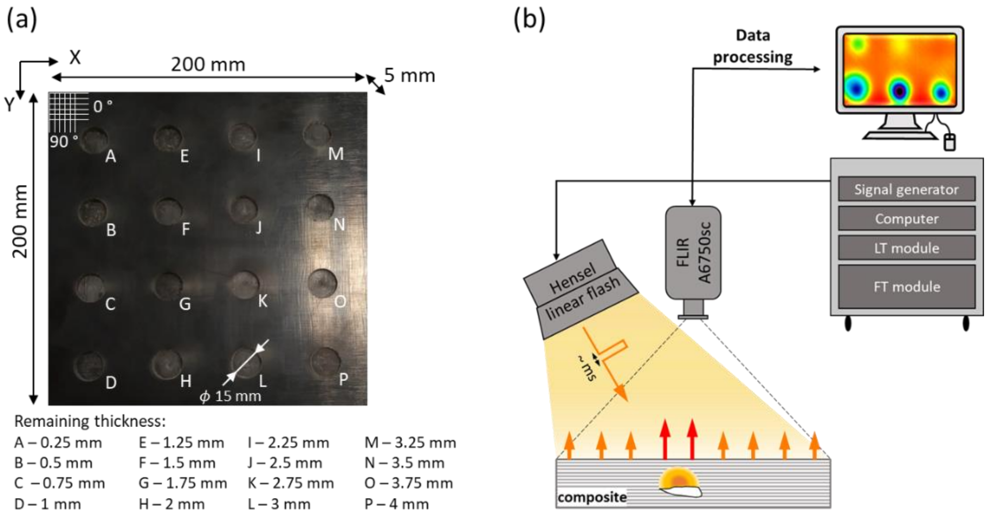

Figure 1*:* *(a) Photograph of the experimental sample; (b) schematic illustration of the experimental setup at UGent-MMS.*

Figure 2(a,b) displays phase contrast images at the frequencies 0.03 Hz and 0.01 Hz, in which it is immediately clear that the lower evaluation frequency provides a deeper inspection of the sample, but where the defect indication becomes distorted due to lateral heat diffusion effects. Figure 2(c), on the other hand, displays the single damage map from the ASBI algorithm, in which all defects are clearly detected and the background non-uniformity is effectively suppressed.

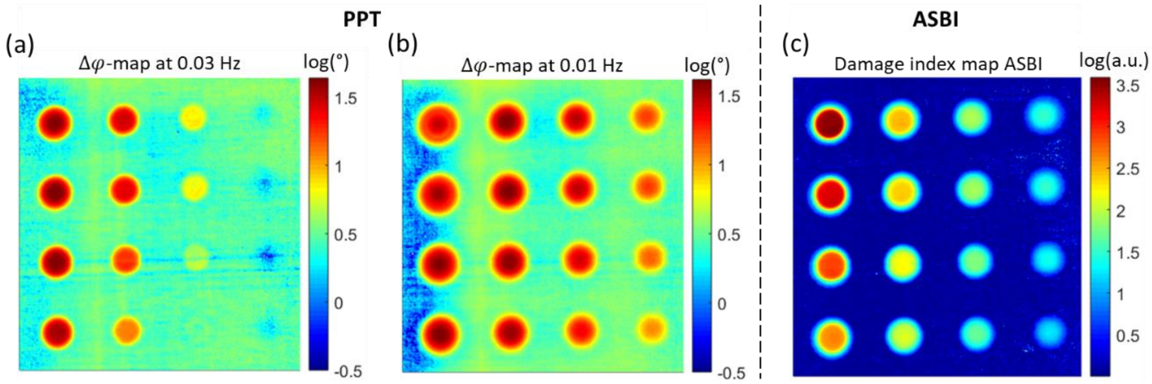

Figure 2: *(a,b) Phase contrast images at 0.03 Hz and 0.01 Hz, respectively; (c) output of the ASBI algorithm.*

Besides providing a high-quality output for defect detection, ASBI can also effectively be used for quantitative depth inversion through model-based calibration curves. This is shown in Figure 3(a) which represents the depth of the detected defects. This depth map allows for accurate through-depth slicing of the inspected material, as illustrated in Figure 3(b). Comparison with the actual defect depths (Figure 1a) indicates the good performance of the ASBI method.

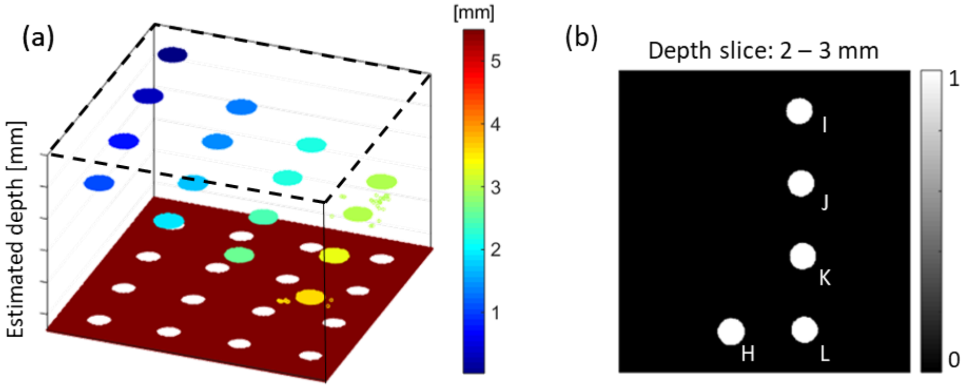

Figure 3: *(a) 3D view of the estimated depth map; (b) depth slice ranging from 2 to 3 mm depth.*

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